PERFORMANCE OF BOTTOM ASH TREATED PEAT SOIL IN IMPROVING BEARING CAPACITY

SONIA SINGGAR AK LEMBANG

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

_____

(Supervisor's Signature)

Full Name : DR. YOUVENTHARAN DURAISAMY

Position : SENIOR LECTURER

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : SONIA SINGGAR AK LEMBANG

ID Number : AA14217

Date :

PERFORMANCE OF BOTTOM ASH TREATED PEAT SOIL IN IMPROVING BEARING CAPACITY

SONIA SINGGAR AK LEMBANG

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2018

DEDICATION

To my beloved family for all support and love

ACKNOWLEDGEMENTS

I would like to express my appreciation towards my supervisor Dr. Youventharan Duraisamy for all the guidance, valuable advice and comments that was given to me throughout the completion of this thesis.

I also want to convey my gratitude to staff of Geotechnical Laboratory, UMP for their consistent guidance and support that was given directly or indirectly throughout of completion of this thesis. Thank you also to my team mates and all my friends that encourage me to complete this thesis.

Last but not least to my beloved parents and siblings. Thank you for all the encouragement, support and love that given.

ABSTRAK

Tanah gambut dengan kekuatan ricih rendah, kebolehmampatan tinggi dan kandungan air permulaan yang tinggi, dianggap tidak sesuai untuk proses pembinaan. Oleh itu, campuran tanah dengan Simen Portland Biasa (OPC) adalah salah satu kaedah yang biasa digunakan untuk merawat tanah gambut. Walau bagaimanapun, disebabkan kos yang tinggi kaedah ini masih bukan kaedah terbaik yang disyorkan untuk tujuan ini. Dalam industri loji kuasa, abu bawah (Bottom Ash) dianggap bahan sisa dengan tempat untuk dilupuskan dan tiada nilai guna semula. Kajian terdahulu menunjukkan campuran abu bawah dengan serbuk simen dijangka dapat menstabilkan tanah gambut dengan mengubah sifat semula jadi. Kajian ini bertujuan untuk mengkaji kapasiti galas dan indeks kumpulan tanah gambut tropika yang stabil di Pantai Timur Semenanjung Malaysia dengan mencampurkan sebahagian simen OPC yang sama dan pelbagai abu bawah. Juga kajian ini akan membincangkan tingkah laku tanah gambut dengan atau tanpa abu bawah dan penstabilan simen. Sebahagian tetap pengikat OPC dan pelbagai bahagian abu bawah (bahan pozzolanic) dalam satu siri ujian makmal telah dijalankan. Semua sampel telah mengalami 3 hari direndam dalam pengalaman air untuk sampel direndam. Sampel tak terbakar telah diuji selepas pencampuran. Peningkatan kapasiti galas sedang dinilai menggunakan ujian California Bearing Ratio (CBR). Keputusan menunjukkan bahawa selepas mencampurkan dengan abu bawah kapasiti galas peningkatan tanah gambut dengan meningkatkan peratusan abu bawah dalam tanah gambut.

ABSTRACT

Peat soil with low shear strength, high compressibility and high initial water content, is deem unsuitable for construction process. Hence soil mixing with Ordinary Portland Cement (OPC) is one of the methods commonly used to treating the peat soil. However due to high cost this method is still not the best method recommended for this purpose. In power plant industry bottom ash considered waste material with nowhere to dispose and no reuse value. Previous research shows bottom ash mix with cement powder is expected to stabilise the peat soil by changing it natural properties. This research aims to study the bearing capacity and group index of stabilized tropical peat soil of East Coast of Peninsular Malaysia by mixing same proportion of OPC cement and various proportion of bottom ash. Also this study will discuss the behaviour of peat soil with or without the bottom ash and cement stabilization. A fixed proportion of OPC binders and various proportion of bottom ash (pozzolanic material) in a series of laboratory test were conducted. All samples have undergone 3 days soaked in water experience for soaked sample. Unsoaked sample was tested after mixing. The improvement in bearing capacity was being evaluated using California Bearing Ratio (CBR) test. The results shows that after mixing with bottom ash the bearing capacity of peat soil increase with increase the bottom ash percentage in peat soil.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

MW	Mega watt
ha	Hectare
%	Percentage
km^2	Kilometre square
mm	millimetre
N	North
E	East
°	Degree
m	Meter
ml	Millilitre
$kN\text{-}m/m^3$	Kilonewton- meter per meter cube
Kg/m^2	Kilogram per meter square
m/s	Meter per second
cm	centimetre
kN/m^3	Kilonewton per meter cube
cm^3	Centimetre cube
g	Gram
m^2	Meter square
cm^2	Centimetre square
cm/s	Centimetre per second
g/cm^3	Gram per centimetre cube
kg	kilogram

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
Al_2O_3	Aluminium Oxide
ASTM	American Standard Test Method
BA	Bottom Ash
BaO	Barium oxide
BS	British Standard
CaO	Calcium Oxide
CBA	Coal Bottom Ash
CBR	California Bearing Ratio
C_C	Coefficient of Curvature
C_U	Coefficient of Uniformity
DMM	Dry Mixed Method
DMJ	Dry Jet Mixing
ESA	Equivalent Standard Axles
FA	Fly Ash
JKR	Jabatan Kerja Raya
K_2O	Potassium Oxide
LL	Liquid Limit
MDD	Maximum Dry Density
MgO	Magnesium Oxide
Na_2O	Sodium Oxide
OMC	Optimum Moisture Content
PA	Pond Ash
P_2O_5	Phosphorus Pentoxide
PI	Plasticity Index
PL	Plastic Limit
RHA	Rick Husk Ash
SEM	Scanning Electron Microscopy
SiO_2	Silicon Dioxide
SO_3	Sulphur Trioxide
TiO_2	Titanium Dioxide
UCS	Unconfined Compression Strength
USCS	Unified Soil Classification System
XRF	x-ray fluorescence

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Peat soil contains a high amount of decomposed and disintegrated plant remains under condition of incomplete aeration and high water content. Around the world there are 400 million ha of peat soil. In Malaysia there are some 3 million ha covered in peat. Table 1.1 shows the proportion of peat soil in Malaysia.

Table 1.1 : Proportion of peat soil in Malaysia (Jon Davies et al., 2010)

State	Area (ha)
Peninsular	642 918
Sabah	111 965
Sarawak	1697 847

Peat soil has unfavourable characteristic such as low bearing capacity, low specific gravity, medium to low permeability, high compressibility, high content of natural water, high water holding capacity, high rates of creep and difficult accessibility (Venuja et al., 2017)

When using peat soil for construction, problem such as instability, slip failure, localized sinking and long term settlement (Venuja et al., 2017) will occur and therefore it is very difficult to use. However due to increase in population and scarcity

of good land for development, peat soil is in demand for construction purpose. Generally there are two ways to improve peat soil i) mechanical method and ii) chemical method. It depends on the engineer's justification or sometimes on client's budget to choose the best method to improve peat. Some will cut and replace the peat, others will treat the soil or just completely avoid from using the soil for construction (which is not the best option). Typically mechanical method consists of 'cut and fill' method, stage construction, preloading, stone columns, piles, vertical drains and lightweight fill and as for chemical method there are deep in-situ mixing and surface stabilization had been introduced to improved expansive soil (clay, peat soil, etc). Among all deep soil mixing is one of the commonly used methods for soil stabilization. This in- situ method involves mechanically mixing of cementitious compound like Ordinary Portland Cement or lime.

For centuries coal has been used as one of the most important energy sources. Approximately 40% of electricity production in the worldwide is based on coal. In Malaysia, 7 of its power plant use coal as a raw material in generating electricity since the year 1988. Table 1.2 shows summarizes of capacity coal power plant in Malaysia.

Table 1.2: Summarizes the capacity of coal powered plant in Malaysia (Marto & Tan, 2016).

Power plant	Commissioning year	Capacity (MW)
Jimah, Negeri Sembilan	2009	1400
Manjung, Perak	2002	2295
Kapar, Selangor	1988	2420
Tanjung Bin, Johor	2006	2100
Mukah, Sarawak	2009	270
PPLS, Sarawak	2006	110
Sejingkat, Sarawak	1997	100

From these power plants Fly ash (FA) and Bottom ash (BA) are generated as one of the waste product. Fly ash has been used in cement industry meanwhile there are still some doubts on how to utilize bottom ash in the industry. Previous studies show that the bottom ash is highly potential in the construction industry as an alternative to existing materials. Therefore to check and validate the benefit involving bottom ash, this research is mainly focused to improve peat soil properties. Bottom ash will work with pozzolanic material in the soil mixing method. Using OPC as the binder, there will be a pozzolanic reaction when these two substances mixed together. In this study, 5% of OPC (binder) and 5% to 20% of Bottom ash was used to mix tropical peat soil.

1.2 PROBLEM STATEMENT

Due to its low shear strength, high compressibility and high initial water content, peat soil is unsuitable for construction process (Venuja et al., 2017). Therefore it is best to avoid because of the instability and settlement problem occurrence if any structures are to be built on it. However due to increasing in development and population, demand of land used for construction is unavoidable. Thus various method and solution are suggested to improve and strengthen peat soil properties. Previous researcher comes with many ways that can be categorized into two

i. Mechanical method
ii. Chemical method

Some of approaches are highly costly and the effectiveness is still questionable. So in order to find the best method, these factors should be considered

- Environmental friendliness
- Cost
- Effectiveness
- Reliability and durability

Mechanical method like cut and replace involve too much time and costly makes many reluctant to choose this method. While chemical method such as deep mixing stabilization appears to be cheap, but it is not very environmental friendly.

REFERENCES

A. Cadersa, A. S. (2014). Use of Coal Bottom Ash as Mechanical Stabiliser in Subgrade Soil. *Journal of Engineering (United States)* .

A. Fauzi, W. N. (2011). Kuatan Clay Properties and Examination of Fly Ash and Bottom Ash Utilization as Soil Stabilizer. *International Journal of Civil Engineering* , 27 - 31.

A. Fauzi, W. N. (2010). Subgrades Stabilization of Kuatan Clay Using Fly Ash and Bottom Ash. *The 8th International Conference on Geotechnical and Transportation Engineering Geotropika* .

A. Manikandan, Y. I. (2017). A Study on Effect of Bottom Ash and Coconut Shell Powder. *International Research Journal of Engineering and Technology (IRJET)* , 550 - 553.

A. Marto, C. (2016). Properties of Coal Bottom Ash From Power Plants in Malaysia and its Suitability as Geotechnical Engineering Material. *Jurnal Teknologi* , 1 - 10.

A. Zahra, B. K. (2015). A Study of Using A Variety of Wasted Materials As Additives In Soil Stabilization. *International Journal of Scientific and Engineering Research* , 317 - 322.

Akbulut S., S. A. (2007). Modification of Clayey Soils using Scrap Tire Rubber and Synthetic Fibers. *Applied Clay Science* , 23-32.

Ampera B, A. T. (2005). Recent Experiences with Cement and Lime-Stabilization of Local Typical Poor Cohesive Soil. *Geotechnik-kolloquium Freiberg* , 121-144.

Awang, A. M. (2012). Morphological and Strength Properties of Tanjung Bin Coal Ash Mixtures for Applied in Geotechnical Engineering Work. *International Journal on Advanced Science, Engineering and Information Technology* , 168-175.

B. McLellan, R. W. (2011). Costs and Cabon Emissions for Geopolymer Pastes in Comparison to Ordinary Portland Cement. *Journal of Cleaner Production* , 1080 - 1090.

Brooks, R. (2009). Soil Stabilization with Fly Ash and Rice Husk Ash. *International Journal of Research and Reviews in Applied Sciences* , 209-217.

C. Rajakumar, T. M. (2015). Effect of Coal Ash in The Stabilization of Expensive Soil for The Pavement. *International Journal of ChemTech Research* , 170 - 177.

C. Rajakumar, T. M. (2015). Experimental Study on Utilization of Bottom Ash to Stabilize Expansive Soil Subgrade. *International Journal of ChemTech Research* , 997 - 1005.

Carreon, G. (2006). *Stabilization of Marginal Soils Using Recycled Materials.* Retrieved from These Sand Dissertations Paper 2473: http://scholarcommons.usf.edu/etd/2473

D. Choudhary, Y. J. (2014). A Detailed Study of CBR Method for Flexible Pavement Design. *International Journal of Engineering Research and Applications* , 239 - 253.

D. Fllughoeft - Hasett, D. D. (2000). Use Bottom Ash and Fly Ash in Rammed-Earth Construction. *North* .

D. Kolay, H. S. (2011). Tropical Peat Soil Stabilization Using Class F Pond Ash From Fired Power Plant. *International Journal of Civil and ENvironmental Engineering* , 79 - 83.

D. Kumar, A. G. (2014). Uses of Bottom Ash in the Replacement of Fine Aggregrate for Making Concrete. *International Journal of Current Engineering and Technology* , 3891-3895.

Durairaj, S. (2016). Importance of Bottom Ash in Preventing Soil Failure . *Research Gate* .

Duraisamy, Y. (2008). Compressibility Behaviour of Tropical Peat Reinforced With Cement Column. *Master of Science* , 784 - 789.

Duraisamy, Y. (2009). *Soil Mechanics Laboratory Manual.* Gambang: Universiti Malaysia Pahang.

E. Lopez Lopez, A. V. (2015). Bearing Capacity of Bottom Ash and Its Mixture With Soils. *Soils and Foundations* , 529 - 535.

I. Deviatkin, J. H. (2016). *Optimal Recycling Combination of Ash in South- East Finland.* Finland: Research Gate.

I. Teong, N. F. (2016). Characterization of Soil Organic Matter in Peat Soil With Different Humification Levels Using FTIR. *IOP Conference Series : Materials Science and Engineering* , 010 - 012.

Ismaiel, H. (2004). Treatment and Improvement of the Geotechnical Properties of Soft Fine-Grained Soils using Chemical Stabilization.

J. Rahman, C. C. (2014). Effect of Additive to The Moisture Content at Different Decomposition Level of Peat. *Journal of Civil Engineering Research* , 59 - 62.

Kolay, P. (2007). Stabilization of Organic Soil by Different Types of Stabilizer. *Research Gate* .

Kowalski, T. D. (2007). Modern Soil Stabilization Techniques. *Annual Conference of The Transportation Association of Canada*, (pp. 1-16). Saskatoon, Saskatchewan.

M. Syahrul, M. S. (2010). The Properties of Special Concrete Using Washed Bottom Ash (WBA) as Partial Sand Replacement. *International Journal of Sustainable Construction Engineering and Technology* , 65 - 76.

Musa, A. (2008). Potentials of Rice Husk Ash for Soil Stabilization. *AUJ.T. 11(4)* , 246-250.

N. Ramzi, S. S. (2016). Physical and Chemical Properties of Coal Bottom Ash from Tanjung Bin Power Plant. *IOP Conference Series : Materials Science and Engineering* , 012 - 056.

Otoko, G. (2014). A Review of A Stabilization Method for The Nigerian Deltaic Peaty Clay (Chikoko). *International Journal of Engineering and Technology Research* , 1298 - 1305.

Otoko, G. (2014). A Review of The Stabilization of Problematic Soils . *International Journal of Engineering and Technology Research* , 1 - 6.

P. Kolay, M. (2010). Peat Stabilization Using Gypsum and Fly Ash. *Feng. Unimas. My* , 1 - 5.

Qubain Bashar, E. S. (2000). Incorporating Sub-grade Lime Stabilization Into Pavement Design. *Transportation Research Board Meeting* .

R. Adon, I. B. (2013). Overview of The Sustainable Uses of Peat Soil in Malaysia with some Relevant Geotechnical Assessments. *International Journal of Integrated Engineering* , 38 - 46.

FKASA (2012). *Civil Engineering Laboratory Manual 3rd Edition.* Gambang: Universiti Malaysia Pahang.

S. Venuja, S. M. (2017). Geotechnical Engineering Properties of Peat, Stabilized with A Combination of Fly Ash and Well Graded Sand. *Engineer: Journal of The Institution of Engineers, Sri Lanka* , 21 - 28.

White, D. (2005). Fly Ash Soil Stabilization for Non-Uniform Subgrade Soils. In *Engineering Properties and Construction Guidelines.* Iowa State University.

Wong, L. (2015). Formulation of An Optimal Mix Design of Stabilized Peat Columns with Fly Ash As A Pozzolan. *Arabian Journal for Science and Engineering* , 1015 - 1025.

Y. Duraisamy, B. H. (2007). Methods of Utilizing Tropical Peat Land for Housing Scheme . *American Journal of Environmental Sciences* , 258 - 263.